16 F-NUMBER FORMULAS

SHORTCUTS TO FASTER PHOTOGRAPHY

The mathematics of photography can be complex and frustrating to photographers seeking the inner secrets. Skimming through the various photo instruction books, you can find a multitude of formulas, charts, graphs and dials, all seemingly designed to confuse and slow down the photographic process. Photographers may spend so much time going through all the data that they lose sight of the subject they intended to photograph. Many professional photographers and photo instructors have found shortcuts that help simplify this process and most of these shortcuts make use of f-numbers—the "key to photography."

Basically, f-numbers are derived from a relationship between the focal length of a lens and the diameter of the aperture of that lens. Simply said, the focal length of a lens, divided by the diameter of the lens's aperture, is an f-number:

50mm lens at 25mm aperture = f/2
200mm lens at 50mm aperture = f/4
20mm lens at 5mm aperture = f/4

Making this aperture smaller or larger until the light doubles or halves creates another f-number. The basic f-number scale used today is: 1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, 32, 45, 64, 90. If you are interested in finding the f-numbers yourself without measuring a lot of lenses, get out your calculator and find the square root of: 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192. The end results will be the f-number scale mentioned above.

The following is a list of 16 photographic shortcuts using f-numbers. You probably won't find a use for all of them, but we're sure that *some* will apply to your specific needs.

1. Lighting ratios. If you had two lights of equal intensity and one was set at a distance of 4 feet from the subject, the second light can be set at the next f-number, 5.6, for a one-stop difference in lighting. The second light could also be set at 8 feet for a two-stop difference. Any unit of measurement could be used instead of feet; for example, meters, inches, miles, or yards. Using f-numbers for distance simplifies the thought process, but if the first light's distance is not an f-number, you can multiply the distance by 1.4 for a one-stop difference, and by two for a two-stop difference.

First light—5 ft.×1.4 = 7 ft. for the second light at a one-stop difference

First light—9 ft.×1.4 = 12.6 ft. for the second light at a one-stop difference

First light—3 ft.×2 = 6 ft. for the second light at a two-stop difference

2. Flash guide numbers. It seems that all the flash units on the market today are rated by guide numbers. When determining which flash to purchase, you need to be able to *compare guide numbers and light output*. A flash guide number is really a multiple of an f-number. Therefore, a flash unit with a guide number of:

10 has one stop less than 14
14 has one stop less than 20
20 has one stop less than 28
28 has one stop less than 40
40 has one stop less than 56
56 has one stop less than 80
80 has one stop less than 110

As you can see, each column is actually f-numbers. If your flash guide number is not an f-number, divide it by 1.4 to get the guide number with half the power, and multiply it by 1.4 to get a guide number with twice the power.

Guide number of 50 ÷ 1.4 = 36, or half power
Guide number of 50 × 1.4 = 70, or twice power

3. Print size and exposure. Due to the rising cost of photographic paper and chemistry, it is important to easily obtain correct exposure using the least amount of paper. Here is a simple method to solve paper waste. Each of the print sizes listed below requires a one-stop increase in exposure. Notice the first number in each size:

1×1.5-inch print
1.4×2-inch print
2.0×3-inch print
2.8×4-inch print
4×5-inch print
5.6×7-inch print
8×10-inch print
11×14-inch print
16×20-inch print
22×28-inch print

If the print size you are using does not fit an f-number, multiply it by 1.4 for the next size up (one stop) or divide it by 1.4 for the next size down (one stop).

Example: Starting with a 10×15 print, to find the next size up: 10 × 1.4 = 14; 15 × 1.4 = 19; or a 14×19 print

4. Extension tube exposure calculation. More and more photographers are becoming interested in photographing macro, close-up, and nature subjects. Here is a simple method for determining extension tube exposure. If you have a 55mm macro lens (which is close to 56mm), an extension tube of 25mm would require an increase of one stop (56mm to 80mm = 1 stop). If you added an additional 30mm tube to this setup, another exposure increase of one stop would be necessary (80mm to 110mm = 1 stop). Again, multiplying a lens that is not an f-number by 1.4 will add one stop in tube extension.

Example: 135mm lens × 1.4 = 189mm total, or a 54mm extension tube

5. Image size is proportional to focus distance. (Best suited for 4×5 cameras.) If the subject is 1 inch on groundglass focused at 11 feet, then:

1.4 inches on groundglass focused at 8 feet and
2 inches on groundglass focused at 5.6 feet and
2.8 inches on groundglass focused at 4 feet and
4 inches on groundglass focused at 2.8 feet

You can also divide a non-f-number distance by 1.4 and then multiply the image size by 1.4.

For example: A 3-inch image focused 10 feet can be changed to a 4.2-inch image (3 × 1.4) at 7 feet (10÷1.4)

6. Large format bellows exposure correction.

An 8-inch lens with 8-inch bellows requires no exposure increase.

An 8-inch lens with 11-inch bellows requires an increase of one stop.

A 5.6-inch lens with 11-inch bellows requires two stops.

For lenses that are not f-numbers, multiply by 1.4 for a one-stop increase, and by 2 for a two-stop increase. As an example: 10-inch lens × 1.4 = 14-inch bellows for one-stop increase in exposure.

7. f-number exposure factor. Ever wonder where the factor chart came from? Here is a clue:

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1× = 0 stops	**8× = 3 stops**
1.4× = .5 stop	**11× = 3.5 stops**
2× = 1 stop	**16× = 4 stops**
2.8× = 1.5 stops	**22× = 4.5 stops**
4× = 2 stops	**32× = 5 stops**
5.6× = 2.5 stops	

8. Slide projector focal length. If you don't have a slide projector screen chart, you can use the following shortcut. Divide the projection distance (ft.) by the screen width (ft.) and multiply by 1.4 for lens length in inches.

For example: 40 ft. projection distance ÷ 10-ft. screen width = 4; 4 × 1.4 = approx. 5.6-in. lens

After finding the focal length of the lens necessary for projection, it is easy to find the other combination:

10 ft. screen	**14 ft. distance**	**2-inch lens**
10 ft. screen	**20 ft. distance**	**2.8-inch lens**
10 ft. screen	**28 ft. distance**	**4-inch lens**
10 ft. screen	**40 ft. distance**	**5.6-inch lens (5.5 inch)**
10 ft. screen	**56 ft. distance**	**8-inch lens**
10 ft. screen	**80 ft. distance**	**11-inch lens**

If you divide the screen size by 1.4, divide the projection distance by 1.4 for use with the same lens. For example:

11 ft. screen	**28 ft. distance**	**3.5-inch lens**
8 ft. screen	**20 ft. distance**	**3.5-inch lens**

9. Hyperfocal distance. Hyperfocal distance is a focus point for a given f-stop on a given lens that gives maximum depth of field to infinity. Each change in f-stop gives a proportional change in the hyperfocal distance. Hyperfocal distance can be calculated by dividing the focal length by the f-stop and multiplying it by 2.8. For example:

45mm lens at f/22 = 5.6 ft. hyperfocal distance
45mm lens at f/16 = 8 ft. hyperfocal distance
45mm lens at f/11 = 11 ft. hyperfocal distance
45mm lens at f/8 = 16 ft. hyperfocal distance
45mm lens at f/5.6 = 22 ft. hyperfocal distance

A change in focal length equal to one f-number will double or halve the respective hyperfocal distance. For example:

22mm lens at f/16 = 2 ft. hyperfocal distance
32mm lens at f/16 = 4 ft. hyperfocal distance
45mm lens at f/16 = 8 ft. hyperfocal distance
64mm lens at f/16 = 16 ft. hyperfocal distance
90mm lens at f/16 = 32 ft. hyperfocal distance

The depth of field for any of these hyperfocal distances is from half that distance to infinity. Here's an example: 22mm lens at f/16 = 2-ft. hyperfocal distance. The depth of field would be 1 ft. to infinity.

10. Depth of field is also proportional to f-numbers. (Depth of field is the zone of acceptable sharpness in front of and beyond the point focused upon.)

56mm lens	**1 ft. depth of field**	**f/22**
40mm lens	**1 ft. depth of field**	**f/16**
28mm lens	**1 ft. depth of field**	**f/11**
56mm lens	**1.4 ft. depth of field**	**f/32**
40mm lens	**1.4 ft. depth of field**	**f/22**
28mm lens	**1.4 ft. depth of field**	**f/16**
20mm lens	**2 ft. depth of field**	**f/16**
20mm lens	**2.8 ft. depth of field**	**f/22**
20mm lens	**4 ft. depth of field**	**f/32**

11. Moving object chart. The moving object chart found in most camera manuals can be reduced to f-numbers.

LENS	OBJECT AT	MOTION	SHUTTER SPEED:
56mm	16 ft.	22 ft/sec	1.1ms or approx. 1/1000
40mm	16 ft.	22 ft/sec	1.6ms or approx. 1/500
28mm	16 ft.	22 ft/sec	2.2ms or approx. 1/500
20mm	16 ft.	22 ft/sec	3.2ms or approx. 1/250

If you change any one item by one f-number, then change any other item by one f-number. For example:

LENS	OBJECT AT	MOTION	SHUTTER SPEED:
56mm	11 ft.	22 ft/sec	.8ms or approx. 1/1000
56mm	16 ft.	22 ft/sec	1.1ms or approx. 1/1000
56mm	11 ft.	32 ft/sec	1.1ms or approx. 1/1000

12. Push film processing. To push normal films, find the normal development time and multiply it by 1.4 for a one-stop push and by 2.8 for a two-stop push. Divide it by 1.4 to pull one stop, etc. This doesn't work with *all* films and developers, but it *does* work with Panatomic-X, Plus-X, Tri-X, HC-110, Microdol-X and D-76.

DEVELOPER	FILM	TIME	PUSH:
HC-110	Pan-X	4 min.	−1
HC-110	Pan-X	5.6 min.	0
HC-110	Pan-X	8 min.	+1
HC-110	Pan-X	11 min.	+2

These push times are approximate and should be used for beginning points when testing for exact push times. Agitation, temperature, dilution variations and shelf-life all have an effect on push times.

13. Magnification produced by diopter lenses is proportional to f-stops:

56mm lens + 1 diopter = .056 magnification
56mm lens + 1.4 diopter = .080 magnification
56mm lens + 2 diopter = .110 magnification
56mm lens + 2.8 diopter = .160 magnification
56mm lens + 4 diopter = .220 magnification
56mm lens + 5.6 diopter = .320 magnification
56mm lens + 8 diopter = .450 magnification
56mm lens + 11 diopter = .640 magnification
40mm lens + 1 diopter = .040 magnification
40mm lens + 1.4 diopter = .056 magnification
28mm lens + 1 diopter = .028 magnification
40mm lens + 1 diopter = .040 magnification
56mm lens + 1 diopter = .056 magnification

Focal length of diopter = 1000mm/number of diopter:

No. 1 = 1000mm	**No. 3 = 333mm**
No. 2 = 500mm	**No. 4 = 250mm**

Maximum focus = diopter focal length
Minimum focus = (diopter ÷ 2) focal length

14. Color temperature. Kelvin color temperature is proportional in f-numbers to the equivalent value in Mireds:

22,000° Kelvin = approximately 45 Mireds
16,000° Kelvin = approximately 64 Mireds
11,000° Kelvin = approximately 90 Mireds
8000° Kelvin = approximately 128 Mireds
5600° Kelvin = approximately 180 Mireds
4000° Kelvin = approximately 256 Mireds
2800° Kelvin = approximately 360 Mireds

15. Angle of view to focal length is proportional to f-numbers (applies to normal and above lenses):

45mm lens = approximately 56°
64mm lens = approximately 40°
90mm lens = approximately 28°
128mm lens = approximately 20°
180mm lens = approximately 14°
256mm lens = approximately 10°
360mm lens = approximately 7°
512mm lens = approximately 5°

16. One final tidbit of information about f-numbers: The prime f-number is 2. Take the square root of it for one stop open (1.4). Double that number (2 × 1.4), and you have one stop down (2.8). Doubling these numbers or halving them will give you f-stops into infinity. If you want to find the exact f-number for half-f-stops, use the following shortcuts:

To find the half-stop between 4 and 5.6, add the two previous f-stops together (2 + 2.8 = 4.8).

To find the half-stop between 8 and 11, add the two previous f-stops together (4 + 5.6 = 9.6).

Here is the full scale from f/1 to f/64:

1	**2.0**	**4.0**	**8.0**	**16.0**	**32.0**	**64.0**
1.2	**2.4**	**4.8**	**9.6**	**19.0**	**38.0**	
1.4	**2.8**	**5.6**	**11.0**	**22.0**	**45.0**	
1.7	**3.4**	**6.8**	**13.6**	**27.0**	**54.0**	

We're sure that you might not find *all* of these shortcuts helpful, but you can select the ones that will make your photo calculations easier and get back to enjoying the simple pleasure of taking photographs! ■